It is impossible from observations on this man or any other few individuals to lay down any definite rules for longevity, but we are certainly justified in concluding from the study of this case that, in the first place, a good family history is a great asset, secondly, that temperate habits of life are important, and third, that if one is so fortunate as to be able to adjust one's life with others and with one's environment in such a way as to avoid worry, this undoubtedly plays a rôle. The physician can aid in advice with regard to habits of life, eating, drinking and other matters of hygiene, but the psychologist has here a great field in training for mental poise. The psychologist must help to show people how to cultivate an unharassed mind and teach them not to worry. In the attainment of longer life the aid of the psychologist may be as important as that of the physician, for old age is a mental as well as a physical phenomenon.

(The details of this research with subsequently collected observations will shortly be published elsewhere.)

STUDIES ON THE GROWTH HORMONE OF PLANTS. V. THE RELATION OF CELL ELONGATION TO CELL WALL FORMATION

BY JAMES BONNER

WILLIAM G. KERCKHOFF LABORATORIES OF THE BIOLOGICAL SCIENCES, CALIFORNIA INSTITUTE OF TECHNOLOGY, PASADENA, CALIFORNIA

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Introduction.—Since the time of Nägeli[1], increase in surface area of the plant cell wall has been frequently attributed to an active intussusception of particles of new material between particles already deposited in the cell wall framework. Intussusception formed, for example, an integral part of the theory proposed by Sachs[2] for the mechanism of growth. Nevertheless, it is undeniable that increase in cell wall material is frequently by apposition of layers of new material upon the surface of layers already laid down. Thus, even the walls of young, actively elongating cells often exhibit a distinctly lamellar structure. In cases of pure apposition, at least, increase in area must be due to processes other than active growth of the wall itself. The work of many investigators, reviewed by Heyn,[3] has indicated that increase in wall area is then by plastic stretching due to the outwardly directed pressure of the cell contents.

Between the supporters of growth by intussusception and those of growth by some form of stretching there has been conflict for some time although Pfeffer[4] and Strassburger[5] attempted to settle the question by showing that it is probable that both forms are to be found. It still seems necessary to

establish the relation of wall formation to increase in wall area for each case of cell elongation which is studied. The present paper is intended to make clear this relation in the *Avena* coleoptile which, in recent years, has been so extensively studied with respect to its growth and tropisms.

Growth of the *Avena* coleoptile is by cell elongation unaccompanied by cell division. Cell elongation is, moreover, able to take place only in the presence of a special "growth substance" normally produced by the tip of the growing coleoptile. For detailed discussions of this growth substance and its relation to the plant reference may be made to Went[6] and to Thimann and Bonner.[7]

In the paper last referred to it was shown that one growth substance molecule in the coleoptile brings about an amount of elongation accompanied, at 27°C., by the deposition as cellulose of about 3×10^5 molecules of glucose. At 15°C. less than one-half of this amount of cellulose is formed during the action of one growth substance molecule. It is clear then, that the growth substance, present in such minute amounts, cannot be an important structural component of the cell wall. Moreover, since the action of one growth substance molecule may be accompanied by the formation of variable amounts of cell wall depending upon the external conditions, it would seem probable that growth substance is not itself directly concerned with wall formation. It will now be shown by direct measurements of wall formation under various conditions, that growth substance is not involved in this process.

Methods.—Sections cut from coleoptiles and placed in growth substance solutions elongate considerably. Similar sections placed in water alone elongate much less. The several conditions governing this elongation have been described in a previous paper (Bonner[8]). Such sections since they have no external source of nutriment, must, if they form cell walls, accomplish it by a transformation of materials already within the cells. Except for the material lost by respiration, their total dry weight must remain constant, and it is necessary to determine only that portion of the total which may be considered as cell wall. For this purpose essentially the same method was used as in a previous paper (Thimann and Bonner[7]), that is the method developed by Hansteen-Cranner[9] for the separation of cell contents from cell wall. The procedure was as follows: sections in most cases 3.7 mm long were cut with a two bladed cutter from coleoptiles approximately 5 mm below the apex. Ten such sections were placed in growth substance of the optimal concentration (Bonner[8]) and ten sections in water alone. After the desired time of growth substance action the elongation of the sections was measured under a microscope with an eyepiece micrometer. The sections were then placed in previously weighed and dried micro-Gooch crucibles. In the bottom of each crucible had been placed a small mat of acid washed asbestos, the mat washed firmly into

place and the whole dried to constant weight at 95°C. The sections, once in the crucible, were thoroughly ground against the wall of the vessel. They were then washed successively with 30 to 50 portions of cold water and an equal amount of boiling water. During the first few washings large amounts of colloidal material, presumably cytoplasm and cell sap were removed. The later washings were clear, and the residue was, then, according to Hansteen-Cranner and to the analytical results of the earlier paper (Thimann and Bonner[7]), to be considered as cell wall. In order to determine the small amounts of material which were used, the weighings were performed upon a Kuhlmann microbalance capable of estimating 0.001 mg.

Experimental Results.—A few series of duplicate determinations were first made in order to establish the accuracy of the method. In table 1 it may be seen that the agreement between duplicate determinations was in all cases quite satisfactory. In subsequent tables, then, only the means

TABLE 1

DUPLICATE DETERMINATIONS OF CELL WALLS

CRUCIBLE/EXPT.	1	2	3	4
	WEIGHT OF CELL WALLS PER 10 SECTIONS, MGS.			
1.	0.75	0.73	0.75	0.69
2.	0.77	0.75	0.71	0.70
3.	0.73	0.73	0.74	0.69
4.				0.71
5.				0.69

of the duplicate or triplicate estimations which were made in each case will be given.

If elongation is due to intussusception of new material in the cell wall, one would expect the amount of cell wall per section to increase, under all conditions, in approximately the same ratio as the length. Table 2 shows that at 25°C. and in the absence of external supply of nutriment this is in fact the case. In the mean the ratio of the wall weights of the two sets of

TABLE 2

INCREASE IN CELL WALL WEIGHT DURING ELONGATION OF SECTIONS AT 25°C.

(Growth Substance Action for 6 Hours)

EXPT.	LN. IN G.S. (ARBITRARY	LN. IN WATER UNITS)	% GROWTH IN G.S.	% GROWTH IN WATER	WT. IN G.S. (MGS.)	WT. IN WATER	LN. IN G.S. / LN. IN WATER	WT. IN G.S. / WT. IN WATER
1.	4.19	3.80	13.2	2.6	0.714	0.609	1.13	1.17
2.	4.41	3.75	19.2	1.7	0.766	0.650	1.18	1.18
3.	4.50	4.01	21.6	8.3	0.865	0.766	1.12	1.13
4.	4.39	3.87	18.7	4.6	0.829	0.700	1.14	1.18
5.	4.56	3.88	23.3	4.9	0.847	0.758	1.17	1.12
						Mean ratios	1.15	1.16

sections having different amounts of elongation is almost exactly equal to the ratio of their lengths. In experiments which will be published in another connection, it has been found that over most of the growth period of the coleoptile (at 25°C.) the total dry weight closely parallels coleoptile length. The fact that at 25°C. these processes fit in well with one another is reflected in the fact that this temperature is approximately optimal for the coleoptile.

Elongation is not of necessity, however, paralleled by formation of cell wall. Coleoptile sections were allowed to extend at 2°C. It was found, as shown in table 3, that considerable elongation takes place at this

TABLE 3

INCREASE IN CELL WALL WEIGHT DURING ELONGATION OF SECTIONS AT 2°C.

(Growth Substance Action for 20 Hours.)

EXPT.	LN. IN G.S. (ARBITRARY	LN. IN WATER UNITS)	% GROWTH IN G.S.	% GROWTH IN WATER	WT. IN G.S. (MGS.)	WT. IN WATER	LN. IN G.S. / LN. IN WATER	WT. IN G.S. / WT. IN WATER
1.	4.19	3.81	13.2	2.9	0.948	0.948	1.10	1.00
2.	4.16	3.85	12.4	4.2	0.944	0.911	1.08	1.03
3.	4.20	3.79	13.6	2.4	0.877	0.858	1.11	1.02
4.	4.19	3.79	13.2	2.4	0.838	0.843	1.11	0.99
5.	4.10	3.70	8.4	0.6	0.730	0.730	1.10	1.00
						Mean ratios	1.10	1.01

temperature if a preliminary hour at 25°C. is allowed. Under these conditions, although 12 to 14 per cent of elongation took place, there was little or no difference in the wall weight of elongated and non elongated sections. Heyn and VanOverbeek[10] have shown that increases in the plasticity of the coleoptile cell walls take place under the influence of growth substance even at 4°C. The elongation of the coleoptile resembles, in its behavior toward low temperature, a process of plastic stretching rather than a process of wall formation.

If growth substance solutions be made also 1 per cent in fructose, greater elongation takes place than in growth substance alone. At the same time, as shown in table 4, even more cell wall is formed than corresponds to the

TABLE 4

INCREASE IN CELL WALL WEIGHT DURING ELONGATION IN FRUCTOSE AND GROWTH SUBSTANCE SOLUTIONS

EXPT.	TEMP.	LN. IN G.S. (ARB. UNITS)	LN. IN WATER	% GROWTH IN G.S.	% GROWTH IN WATER	WT. IN G.S. (MGS.)	WT. IN WATER (MGS.)	LN. IN G.S. / LN. IN WATER	WT. IN G.S. / WT. IN WATER
1.	25°	4.88	3.99	32	8	1.020	0.795	1.22	1.28
2.	25°	5.26	3.99	40	8	1.185	0.780	1.32	1.52
3.	25°	4.86	3.77	31	2	0.785	0.555	1.29	1.42
4.	25°	4.87	3.78	32	2	0.925	0.645	1.29	1.44
5.	2°	4.08	3.78	11	2	0.790	0.800	1.08	0.99
						Mean ratios (25°C.)		1.28	1.42

increase in length. At 2°C., however, fructose has no effect upon wall deposition. Wall formation is, then, more affected than is elongation by carbohydrate as well as by low temperature.

Summary.—Elongation is not of necessity attended by a corresponding amount of wall formation. A given amount of elongation may be attended by more than the normal amount of wall deposition as in fructose solution, or practically no wall may be laid down, as at 2°C. Increase of wall area due primarily to active intussusception of new material is therefore excluded, at least in the case of the *Avena* coleoptile.

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[3] Heyn, A., *Rec. trav. bot. neerl.*, **28**, 113 (1931).
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A TEST OF THE POSSIBLE EFFECTS OF VISUAL STIMULI UPON THE HAIR COLOR OF MAMMALS[1]

BY FRANCIS B. SUMNER

SCRIPPS INSTITUTION OF OCEANOGRAPHY, LA JOLLA, CALIFORNIA

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The general tendency of ground-dwelling animals to match the color of the soil or rocks on which they dwell has long been recognized. Some striking cases of this phenomenon have been reported in recent years among the rodents. Dice[2] has described certain extraordinarily dark, as well as extraordinarily pale, members of the genus *Perognathus*, inhabiting black lava fields and white gypsum sands, respectively, in New Mexico. Benson[3] has presented an admirable colored plate of these two species and entered into a thorough discussion of their ecological relations. The present writer[4] has devoted considerable attention to an almost equally striking member of the genus *Peromyscus*, found upon beaches and dunes of pure white sand on the Florida coast (this mouse was first described by A. H. Howell[5]).

It would seem impossible for any unprejudiced observer to doubt the existence in such cases of some causal relation between the color of the animal and that of its more familiar background. However, the mechanism by which the former is brought into conformity with the latter is by